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FRICTION STIR PROCESSED AA6061 WITH B_4C – GRAPHITE HYBRID SURFACE COMPOSITE AND ITS MECHANICAL BEHAVIOUR

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ABSTRACT

In this study, A6061-B_4C-Graphite hybrid surface composites were fabricated with different volume percentages using micron sized particles via friction stir processing technique in order to increase the surface mechanical properties. Tool rotational speed and traverse speed were fixed at 710 rpm and 40 mm/min respectively. A groove was provided on the 5 mm thick A6061 plates and packed with B_4C and graphite particles. The fabricated surface composites have been examined by an optical microscope in order to verify the dispersion of reinforcement particles and found that B_4C and Graphite particles are uniformly dispersed in the stir zone. It is also observed that the hardness at higher volume percentage increases due to the presence of hard B_4C particles. The examined mechanical properties have been related to microstructure.

KEYWORDS: Surface composites, Friction stir processing technique, B_4C reinforcement particles, Microstructure & Mechanical properties

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Original Article

INTRODUCTION

Friction stir processing (FSP), a solid-state technique based on the principle of friction stir welding, is used for material processing in order to change the microstructures and mechanical properties of surface composites and to fabricate the surface composites [1,2] Firstly the tool without pin is used and traverses along the grove consisting of reinforcement particles thus forging it. Later the tool with a pin is used and moves along the desired line to cover the region underneath the shoulder. Friction between the tool and workpiece results in localized heating that softens and plasticizes the workpiece. During this process, the material undergoes plastic deformation, thus resulting in grain refinement to improve its mechanical properties.

The 6000 series aluminum alloys are heat treatable and widely used in automotive industry due to their specific mechanical properties, corrosion resistance and formability [3,4]. Thealuminum alloy is getting strengthened when it is reinforced with the hard ceramic particles like Al_2O_3, B_4C, and Sic etc. These alloys have started to replace cast iron and bronze to manufacture wear resistance parts. 6061 alloy is widely used in numerous engineering applications including transport and construction where superior mechanical properties such as tensile strength, hardness etc are essentially required [5]. Boron carbide particulate reinforced aluminum composites

possess the unique combination of high specific strength, high elastic modulus, good wear resistance and good thermal stability [6].

Boron carbide (B_4C) has excellent chemical and thermal stability, high hardness and low density and is used for manufacturing of arm or tank, neutron shielding material, the B4C coating is applied on copper and steel using various methods which are extensively used in nuclear industries [7-11].

To increase the material properties AA 6061 alloy in this work is mixed with B_4C and graphite mixture for preparing the metal composite. The mechanical property of the composite metal is tested using hardness tester.

EXPERIMENTAL PROCEDURE

The composition of the AA6061 aluminum alloy is given in Table1

Table 1: Chemical Composition of AA6061 Aluminium Alloy

Al Alloy	Si	Fe	Cu	Mn	Mg	Cr
6061	0.4-0.8	0.7 max	0.15-0.4	0.2-0.8	0.8-1.2	0.15-0.35

In this study, AA6061 plate with dimensions 120mm×100mm×5mm is used as a Base material. A square groove is made on the advancing side of the plate which is 1 mm far away from the center line of the tool rotation on the AA6061 plate. In order to produce the surface composite 30 µm B_4C and Graphite particles are reinforced into the groove. A Specially designed tool is used in the friction stir processing technique. The tool is made up of material high chromium high carbon steel. A non-consumable high-speed steel tool is used for welding 6061 Al alloy having the shoulder diameter of 20 mm and the tool has a probe (tool pin). The tool has the square shaped probe. The height of the square-shaped probe is 5 mm The FSP tool was subjected to heat treatment to improve its hardness. The hardness of tool after heat treatment is around 54 HRC.

The B_4C-Graphite particles were compressed into the groove and the top surface of the groove was closed with anFSP tool without the pin to prevent the particles from scattering during FSP. In the next stage, the tool is plunged with the pin into the plate to stir the material along the reinforcement to produce the surface composites. The schematic diagram of FSP to produce surface composites is as shown in the figure. The rotational and traverse speeds were taken as 710 rpm and 40 mm/min respectively.

After FSP, microstructural observations were carried out at the cross section of Stir Zone of the surface composite mechanically polished with 2% of HF. Microstructure changes observed by the optical microscope in the Stir zone.

Microhardness test was carried out by using Brinells Hardness tester with diamond indenter and load applied was 10kg at the cross section of Surface composite normal to the FSP direction.

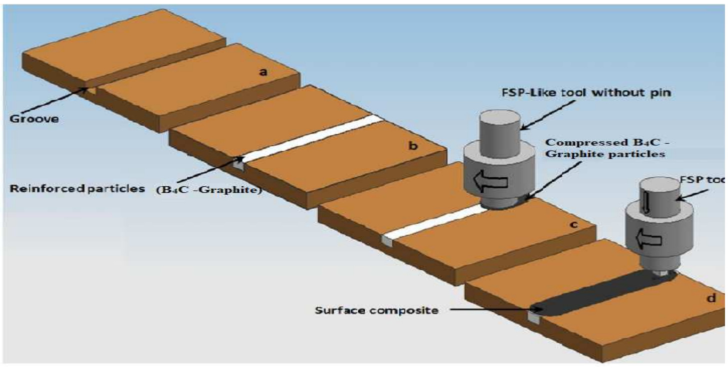


Figure 1: Schematic Diagram of FSP

Figure 2: FSP Tool

(a)

(b)

(c)

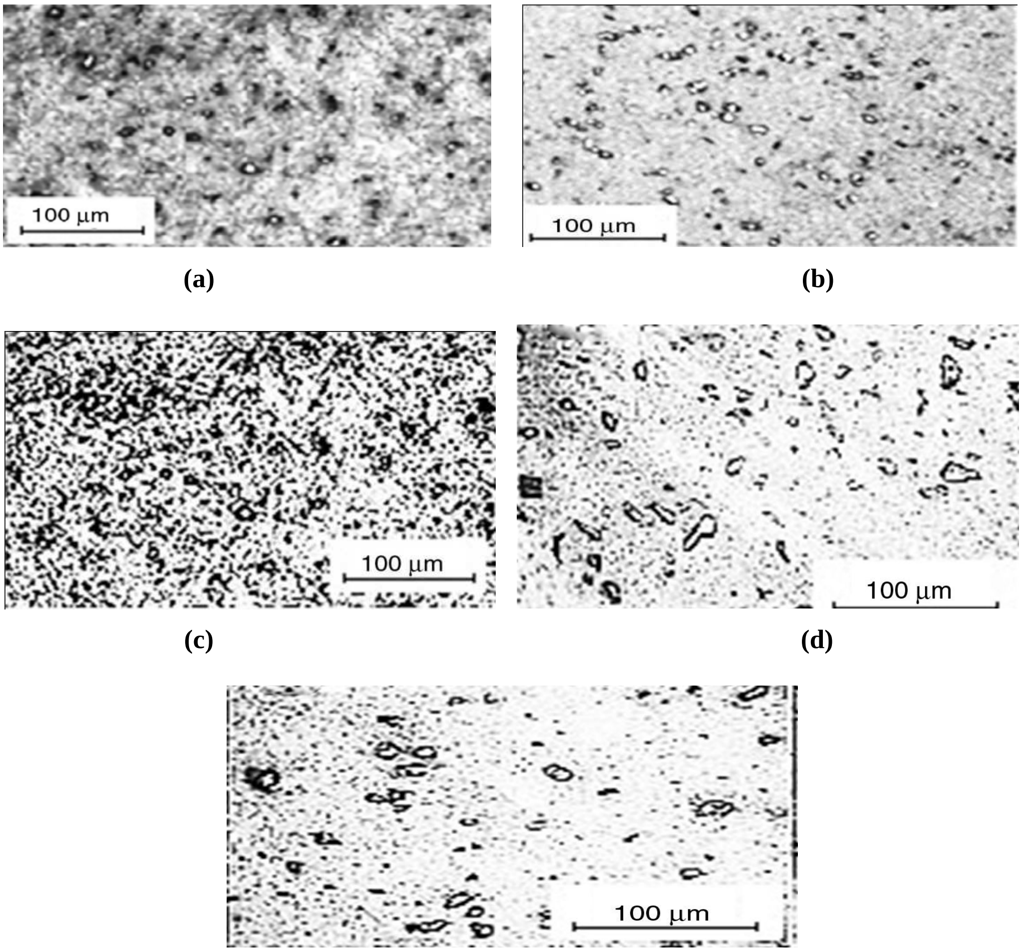
(d)

Figure 3: Surface Morphologies of B$_4$C-Graphite-A6061 Surface COMPOSITE Made with Different Volume Percentages
(a) 12% B$_4$C – 1% Graphite (b) 10% B$_4$C – 1% Graphite
(c) 8% B$_4$C – 1% Graphite (d) 4% B$_4$C – 1% Graphite

RESULTS AND DISCUSSIONS

Microstructure

The specimens for metallographic examination were sectioned to the required size from the Stir zone which is traverse to the processing zone. The metallurgical micrographs of the defect-free FSP specimens are shown in the figure. It is observed that the reinforced particles are dispersed uniformly in the processed zone. This is due to the position of the groove exactly tangential to the pin. It is also observed that, severe plastic deformation and frictional heating in the SZ during FSP resulted in the generation of recrystallized equiaxed microstructure which is due to the occurrence of dynamic recrystallization(DRX) [12]. It is considered that a fine and equiaxed grain structure could be obtained by the FSP with the uniform dispersion of B_4C-graphite particles.



(a) (b) (c) (d) (e)

Figure 4: Optical Microstructures of B_4C-Graphite-A6061 Surface Composite Made with Different Volume Percentages
(a) 12% B_4C – 1% Graphite (b) 10% B_4C – 1% Graphite
(c) 8% B_4C – 1% Graphite (d) 6% B_4C – 1% Graphite
(e) 4% B_4C – 1% Graphite

HARDNESS

The hardness of the samples are tested using Brinells Hardness Tester. The workpiece is divided into Centre processed Zone, Parent Metal-Left and Parent Metal-Right. Each of these zones of the workpiece is tested using Brinells

hardeness tester to know the strength of the metal The hardness value for various specimen along various zones are taken using Brinells Hardness Number (BHN) and their hardness value is as shown below.

Table 2: Hardness Value for Various Specimen

S. No	B_4C in %	Graphite in %	Parent Metal Left (BHN)	HAZ left (BHN)	Center Processed Zone(BHN)	HAZ Right (BHN)	Parent Metal Right (BHN)
1	0	0	78.67	86.5	114.61	92.4	80.65
2	2	1	88.56	114.2	123.71	106	80.81
3	4	1	89.14	125	134.46	121	93.2
4	6	1	96.41	146	166.62	136	97.42
5	8	1	101.54	126	139.71	120	102.25
6	10	1	98.31	118	132.46	109	103.4
7	12	1	97.25	117	119.58	105	106.62

As per the reading in the table, it can be observed that as the percentage proportion of B4C increases in the reinforced composite material the hardness value proportionately increases up to 8% addition of after B_4C particles after which the hardness starts decreasing showing the saturation limit. Hence it can be suggested that the reinforcement of 8% of B_4C-0.5 Gr hybrid reinforcement can be used to fabricate AA6061 alloy in order to achieve improved properties over the surface.

CONCLUSIONS

- Friction Stir processing of AA6061 alloy with the various proportion of B_4C –Graphite composite was carried out in this experiment and their hardness value is measured.
- The maximum hardness of 139 BHN was obtained with the welding speed of 40mm/min at 710 rpm
- The reinforcement percentage was 8% B_4C and 0.5% Graphite hybrid composite Defect-free and sound surface composites were fabricated within the range of selected parameters.
- The reinforcement particles(B_4C-Graphite) were distributed uniformly in the processed Zone. This may due to the position of the groove exactly tangential to the tool pin.

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